

HYD 495

HYD 495

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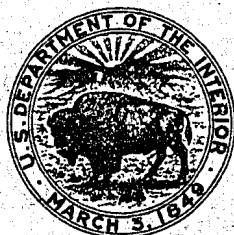
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

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HYDRAULIC MODEL STUDIES OF BULLY CREEK
DAM CANAL OUTLET WORKS
VALE PROJECT--OREGON

Hydraulic Laboratory Report No. Hyd-495

DIVISION OF RESEARCH



OFFICE OF ASSISTANT COMMISSIONER AND CHIEF ENGINEER
DENVER, COLORADO

January 9, 1963

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UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

Office of Assistant Commissioner and Chief Engineer	Laboratory Report No. Hyd-495
Division of Research	Compiled by: D. L. King
Hydraulics Branch	Checked by: T. J. Rhone
Denver, Colorado	Reviewed by: W. E. Wagner
January 9, 1963	Submitted by: H. M. Martin

Subject: Hydraulic model studies of Bully Creek Dam canal outlet works--Vale Project, Oregon

PURPOSE

The purpose of this model study was to observe the flow conditions on the chute, in the hydraulic jump stilling basin, and in the downstream channel to determine any possible hydraulic improvements in the preliminary design.

CONCLUSIONS

1. No changes in the preliminary design were found to be necessary. Performance of the chute and stilling basin was satisfactory for both the maximum discharge of 288 second-feet and the normal discharge of 110 second-feet, Figure 7.
2. Erosion tests indicated that the stilling basin effectively dissipated the energy of the high velocity flow and that no serious erosion would occur at the end of the basin, Figure 8.
3. Riprap studies showed that the proposed rock riprap would give adequate protection against possible erosion due to bottom velocity and wave action in the downstream channel during the maximum discharge, Figure 9.
4. Piezometers placed at selected points in the chute and stilling basin and in one chute block indicated that pressures were within allowable limits in all parts of the structure. Subatmospheric pressures recorded on the chute in the vicinity of the toe of the hydraulic jump and on the chute block did not occur often enough to warrant modification of the basin or the chute blocks.
5. Wave heights in the downstream channel were observed to be less than 1 foot in height.

6. The tailwater could be lowered only 1.4 feet due to the physical configuration of the canal. With this minimum possible tailwater the toe of the hydraulic jump remained on the sloping chute and sweepout could not be achieved.

7. Tests comparing performance of the stilling basin with and without the chute blocks indicated that the chute blocks apparently were not necessary for efficient operation of the basin, however, the blocks were retained in the design.

INTRODUCTION

Bully Creek Dam, located about 8 miles northwest of Vale, Oregon, Figure 1, is one of the principal features of the Vale Project. The dam is a rolled earthfill structure about 104 feet high and 3,000 feet long, Figure 2. The overflow spillway is located in the right abutment of the dam, and the outlet works, located to the left of the spillway, divides into the creek outlet works and a canal outlet works, Figure 3. The model studies for the canal outlet works are described in this report. Studies of the Bully Creek outlet works are described in Hydraulics Branch Report No. Hyd-494.

The canal outlet works, controlled by a single 3-foot 3-inch square high pressure slide gate, Figure 4, has a maximum design discharge capacity of 288 second-feet, which is the bank-full capacity of the canal, and a normal operating discharge of 110 second-feet. The gate is sized to pass the required canal releases for low heads while fully opened but will be only partially opened to pass the maximum and normal discharges for higher reservoir elevations. The gate discharges on to a 2:1 sloping diverging chute, into the hydraulic jump stilling basin, Figure 5, and then into the canal.

THE MODEL

The 1:9.75 model of the Bully Creek canal outlet works consisted of the high pressure slide gate, the 2:1 sloping diverging chute, the hydraulic jump stilling basin, and a portion of the canal. The model arrangement is shown in Figure 6.

The chute floor and the stilling basin were constructed of plywood treated to resist swelling and the warped surfaces of the chute training walls were formed with concrete. The stilling basin included chute blocks and a dentated end sill. The canal was initially shaped using sand with an average size of 0.8 millimeter; a 2-1/2-inch-thick layer of 1-1/2-inch-diameter gravel was later placed in the canal to represent the proposed rock riprap.

Two piezometers were placed in the chute, 12 in the right training wall of the stilling basin, and 10 on one chute block to investigate the possible occurrence of adverse subatmospheric pressures or unusually high impact pressures.

Water was supplied to the high pressure slide gate through a baffled manifold connected directly to the laboratory supply system. Discharges through the model were measured with volumetrically calibrated Venturi meters which are permanent laboratory installations.

The head on the gate was measured with pressure taps located upstream from the miter bend, Figure 6. The tailwater was controlled with an adjustable tailgate, and tailwater elevations were determined with a staff gage located in the center of the channel at approximately Station 15+26. Tailwater settings corresponded to the normal depth determined from the design criteria of the canal.

THE INVESTIGATION

The investigation was concerned primarily with determining the efficiency of operation of the chute and stilling basin through observation and testing. In addition, general operating characteristics were noted for use in research investigations.

The Recommended Stilling Basin

Initial operation of the model showed that the performance of the stilling basin was satisfactory for both the maximum discharge of 288 second-feet and the normal discharge of 110 second-feet, Figure 7. Therefore, no changes were made in the preliminary design. The testing program was continued to more accurately determine the operating characteristics of the outlet works.

Erosion test. --The canal downstream from the stilling basin was shaped with sand with an average size of 0.8 millimeter, Figure 8A, and subjected to 4 hours' operation (equivalent to about 12 hours' prototype operation) at the maximum discharge of 288 second-feet, tailwater elevation 2456.38. No serious erosion occurred in the canal immediately downstream from the stilling basin. The 4:1 slope was somewhat steepened due to material being pulled down the side slopes toward the basin and some material was deposited on the downstream face of the den-tated end sill, Figure 8B. No material was deposited inside the basin.

Riprap test. --The proposed rock riprap was represented in the model by a 2-1/2-inch-thick layer of gravel with a maximum diameter of 1-1/2 inches. The riprap was subjected to 4 hours' model operation at the maximum discharge of 288 second-feet, tailwater elevation 2456.38. The condition of the riprap before and after the erosion test is shown in Figures 8C and D. There was no apparent movement of the riprap in any part of the channel, indicating that adequate protection would be provided.

Pressures. --Both static water manometer pressures and dynamic instantaneous pressures were recorded for each of the 24 piezometers in the model. Piezometer locations are shown in Figure 9. Piezometers 1 and 2 were placed in the chute, Piezometers 3-14 were placed on the right training wall of the stilling basin, and Piezometers 15-24 were placed in the second chute block from the left wall of the basin.

Table 1 lists the static and dynamic pressures; dynamic pressure records for piezometers located on the chute and on the chute blocks are shown in Figure 10.

The static water manometer pressures were in all cases above atmospheric; however, the instantaneous dynamic pressure record indicated subatmospheric minimum pressures at Piezometers 1 and 2 on the chute, Piezometers 4 and 7 on the stilling basin training wall, and all piezometers on the chute block. The lowest pressure, 23.4 feet of water below atmospheric, was recorded at Piezometer 16 on the chute block. A pressure of 21.5 feet of water below atmospheric occurred at Piezometer 21, also on the chute block. It should be noted that these pressures prevailed less than 1 percent of the time; therefore, it is doubtful that cavitation damage will occur.

Waves. --Waves observed in the downstream channel were observed to have a maximum height of about 1 foot for the maximum discharge of 288 second-feet. Waves occurring at the normal discharge of 110 second-feet were negligible. No attempt was made to determine the frequency at which the waves reached the banks of the channel because of their very small size in the model.

Tailwater sweepout test. --The tailwater was lowered 1.4 feet below the design tailwater for both the maximum and normal discharges. This is the lowest possible tailwater for the given canal cross section. For this minimum tailwater the toe of the hydraulic jump remained on the sloping chute and sweepout could not be achieved. This indicates that the margin of safety between the design tailwater and the tailwater at which the hydraulic jump

exposes the chute blocks and begins to move downstream in the basin is something greater than 1.4 feet, an adequate safety margin for a known canal section. Operation of the basin with the lowered tailwater is shown in Figure 11.

Water surface profiles. --Average water surface profiles were determined for the recommended stilling basin, Figure 12, and used in conjunction with the pressure data as aids in the structural design of the basin training walls. Data were plotted for both the maximum and normal discharges and the pressure profiles were based on the average static pressures measured by water manometers at Piezometers 1, 5, 8, 11, and 14. The figure shows close agreement between the pressure profiles for both discharges. The figure also shows that the pressure profiles are somewhat lower than the observed water surface profiles, which is probably due to the bulking effect of entrained air in the flow and the difficulty in measuring the effective water depth.

Operation of the stilling basin without chute blocks. --The chute blocks at the upstream end of the stilling basin were removed to determine whether they were necessary for efficient operation of the basin. Observation at both the normal and maximum discharges, Figure 13, indicated that the basin performed satisfactorily without chute blocks. Turbulence at the end of the basin appeared to be somewhat increased for the maximum discharge, but the operation was entirely satisfactory. No change in the flow conditions was noted for the normal discharge. Water surface profiles measured with the chute blocks removed from the stilling basin are shown in Figure 14. Comparison of Figures 12 and 14 shows that a higher roller occurs near the midpoint of the basin with the chute blocks installed, indicating that the blocks induce a more complete dissipation of energy in the upstream end of the basin.

Although the results of this test indicated that the basin operated satisfactorily without chute blocks, it was suggested that the chute blocks be retained for use in future research. The prototype basin can be easily unwatered for inspection of the chute blocks to determine if the subatmospheric pressures indicated in the model might also exist in the prototype to such an extent as to cause cavitation damage.

Table 1

**STILLING BASIN, CHUTE, AND CHUTE BLOCK PRESSURES
PROTOTYPE FEET OF WATER**

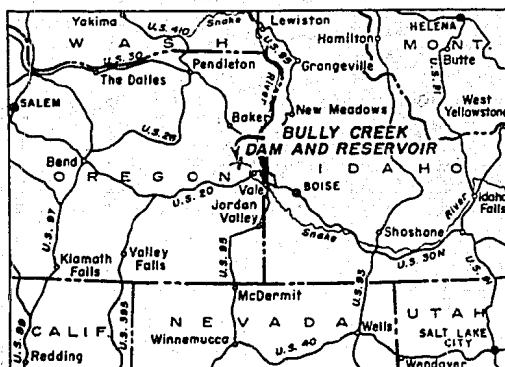
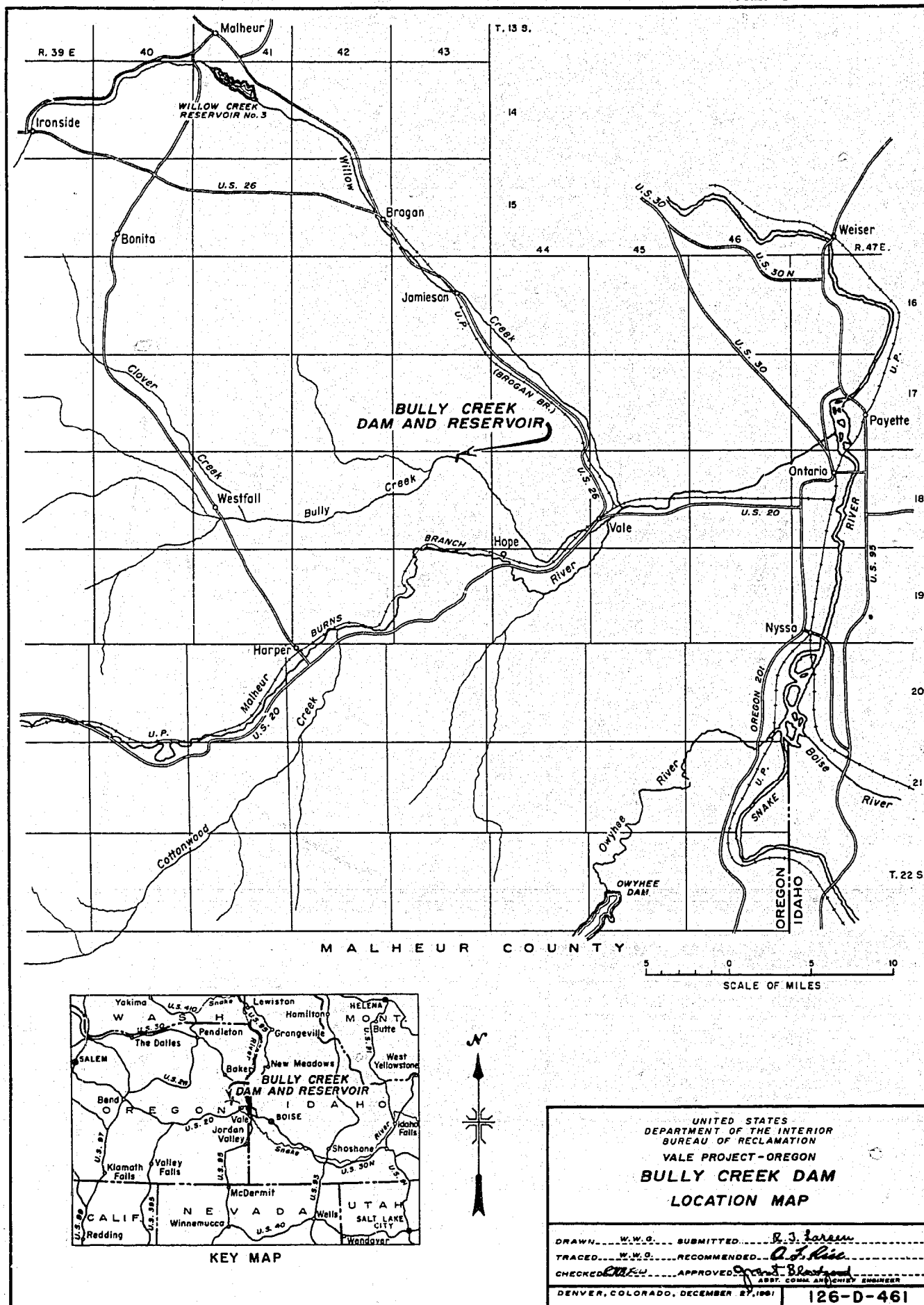
Piezometer No.	Q = 110 cfs						Q = 288 cfs					
	Static			Dynamic			Static			Dynamic		
	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
Chute												
1	3.6	2.9	3.3	10.7	-10.7	1.0	3.7	2.4	3.1	30.2	-18.5	1.0
2	3.6	2.9	3.3	24.9	-17.1	0	3.0	2.3	2.7	18.0	-12.2	0
Stilling Basin												
3	--	--	--	--	--	--	--	--	--	--	--	--
4	2.1	1.5	1.9	2.7	-0.2	1.5	1.6	0.7	1.2	2.7	-2.0	1.0
5	7.1	6.7	6.9	16.6	12.7	14.6	7.7	7.4	7.1	27.3	7.8	16.6
6	--	--	--	--	--	--	--	--	--	--	--	--
7	2.9	2.0	2.4	1.2	0	0.8	2.9	1.7	2.3	3.5	-2.0	0.4
8	7.3	7.1	7.2	8.8	5.9	7.3	7.5	6.4	7.0	15.6	2.0	7.6
9	--	--	--	--	--	--	--	--	--	--	--	--
10	4.0	3.2	3.5	Erroneous data			4.4	3.1	3.8	Erroneous data		
11	8.9	7.7	8.3	8.8	7.3	8.1	9.0	7.7	8.4	11.3	4.9	8.3
12	--	--	--	--	--	--	--	--	--	--	--	--
13	3.8	3.5	3.7	3.9	3.1	3.3	5.0	3.6	4.3	6.3	2.5	5.1
14	8.8	8.5	8.7	8.8	8.2	6.8	10.0	9.5	9.8	8.6	11.9	10.3
Chute Block												
15	10.0	9.6	9.8	22.4	1.5	13.7	12.7	11.8	12.3	34.1	-8.8	14.6
16	7.0	6.4	6.8	17.6	-11.7	3.9	6.5	5.5	6.1	31.2	-23.4	3.9
17	6.7	6.3	6.5	16.6	-2.9	6.3	6.6	5.6	6.1	28.3	-6.8	6.8
18	6.9	6.5	6.7	14.0	0	4.9	6.4	6.0	6.2	21.9	-9.8	4.9
19	7.5	7.2	7.4	10.7	3.9	7.3	7.2	6.9	7.1	18.5	-2.0	7.8
20	7.0	6.6	6.9	9.8	3.9	6.8	6.1	5.8	6.0	16.6	-3.9	6.8
21	5.1	4.5	4.8	9.8	0	5.9	0.8	1.7	1.3	25.4	-21.5	2.0
22	5.0	4.7	4.9	9.2	2.4	6.7	3.2	2.5	2.9	15.9	-6.1	3.7
23	10.1	9.6	9.9	15.6	2.0	8.8	13.3	12.7	13.0	34.1	-7.8	13.7
24	6.3	6.1	6.2	10.7	2.9	6.8	5.9	5.5	5.8	25.4	-6.8	6.8

Piezometer locations shown in Figure 9.

Blank spaces indicate that piezometer is at or above water surface.

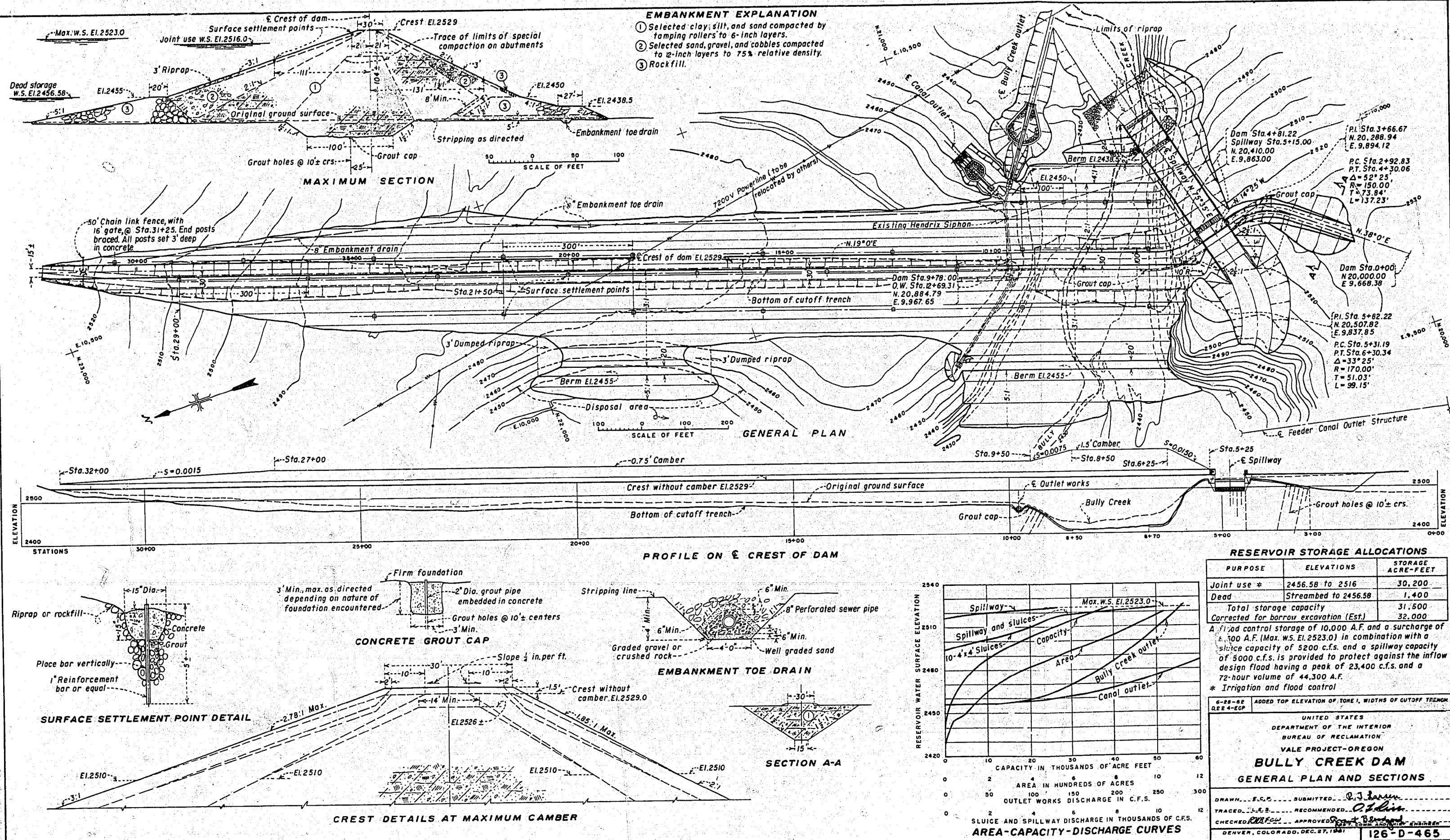
Negative signs indicate subatmospheric pressures.

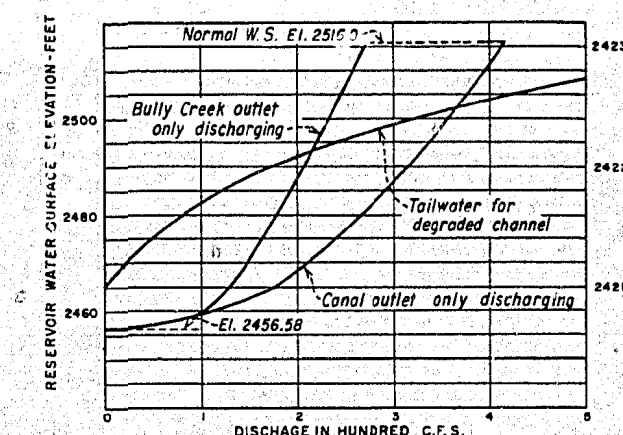
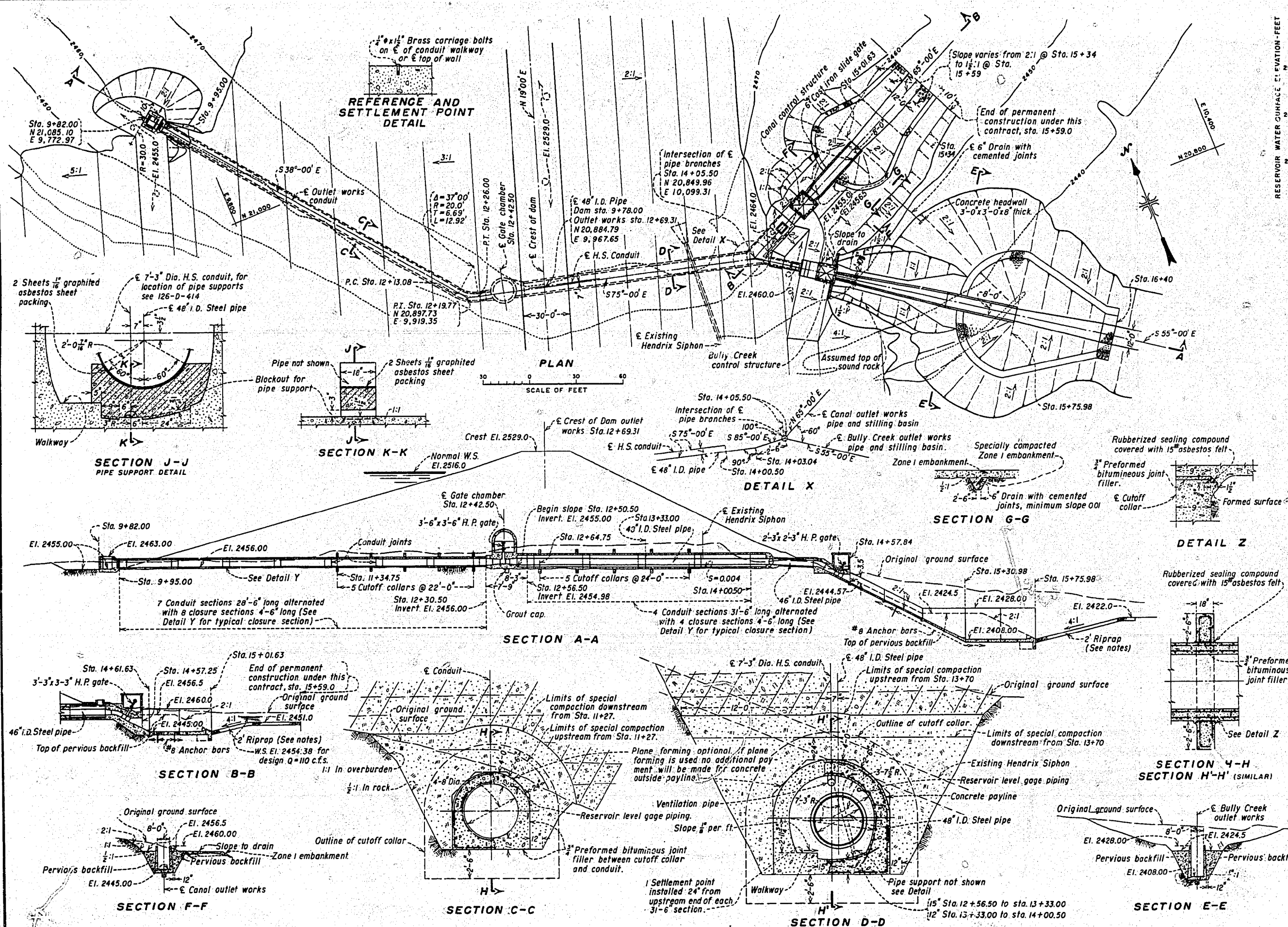
FIGURE I
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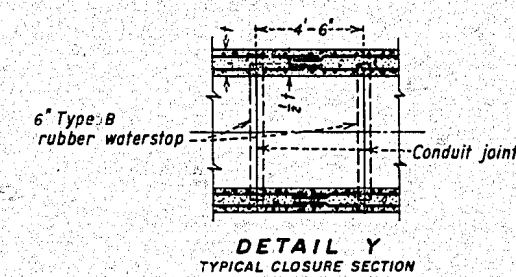
UNITED STATES DEPARTMENT OF THE INTERIOR BUREAU OF RECLAMATION	
VALE PROJECT-OREGON	
BULLY CREEK DAM	
LOCATION MAP	
DRAWN... W.W.O.	SUBMITTED... <i>R. J. Laramie</i>
TRACED... W.W.O.	RECOMMENDED... <i>A. F. Rice</i>
CHECKED... <i>W. W. O.</i>	APPROVED... <i>W. W. O.</i>
DENVER, COLORADO, DECEMBER 27, 1961	
126-D-461	

FIGURE 2
REPORT HYD.-495





DISCHARGE TAILWATER CURVES



CONCRETE FINISHES

Surfaces covered by fill or by second stage concrete F1, U1. Stop log seat U3. Floors of control houses: U3. Outlet works chute walls and floors where required U3, F4. See Dwg. 126-D-411-412-413. Outside exposed walls of control houses: F3. All other surfaces: F2, U2.

NOTES

For general concrete outline notes see Dwg. 40-D-5530. Electrical conduit, control piping, reservoir level gage piping, reinforcement, trashracks, ventilation system, miscellaneous metal work, piping, drains and apparatus not shown completely. If material at downstream ends of stilling basins is suitable rock, excavation shall be completed to channel profile omitting riprap as directed by the contracting officer.

REFERENCE DRAWINGS

DAM-GENERAL PLAN AND SECTIONS	126-D-465
OUTLET WORKS	126-D-466
INTAKE STRUCTURE	126-D-409
GATE CHAMBER	126-D-410
BIFURCATION AND CANAL CONTROL STRUCTURE	126-D-412
BULLY CREEK CONTROL STRUCTURE	126-D-411
STILLING BASINS	126-D-413
STEEL OUTLET PIPE-PLAN AND SECTIONS	126-D-414
GATE CHAMBER AND CONDUIT VENTILATION SYSTEM	126-D-416
RESERVOIR LEVEL GAGE PIPING	126-D-457

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
VALE PROJECT-OREGON
**BULLY CREEK DAM
OUTLET WORKS
PLAN AND SECTIONS**

DRAWN: J.M.C. SUBMITTED: P.D. McDaniel
TRACED: W.W.G. RECOMMENDED: P.D. McDaniel
CHECKED: T.B.W. APPROVED: P.D. McDaniel
DENVER, COLORADO, DECEMBER 20, 1931

126-D-408

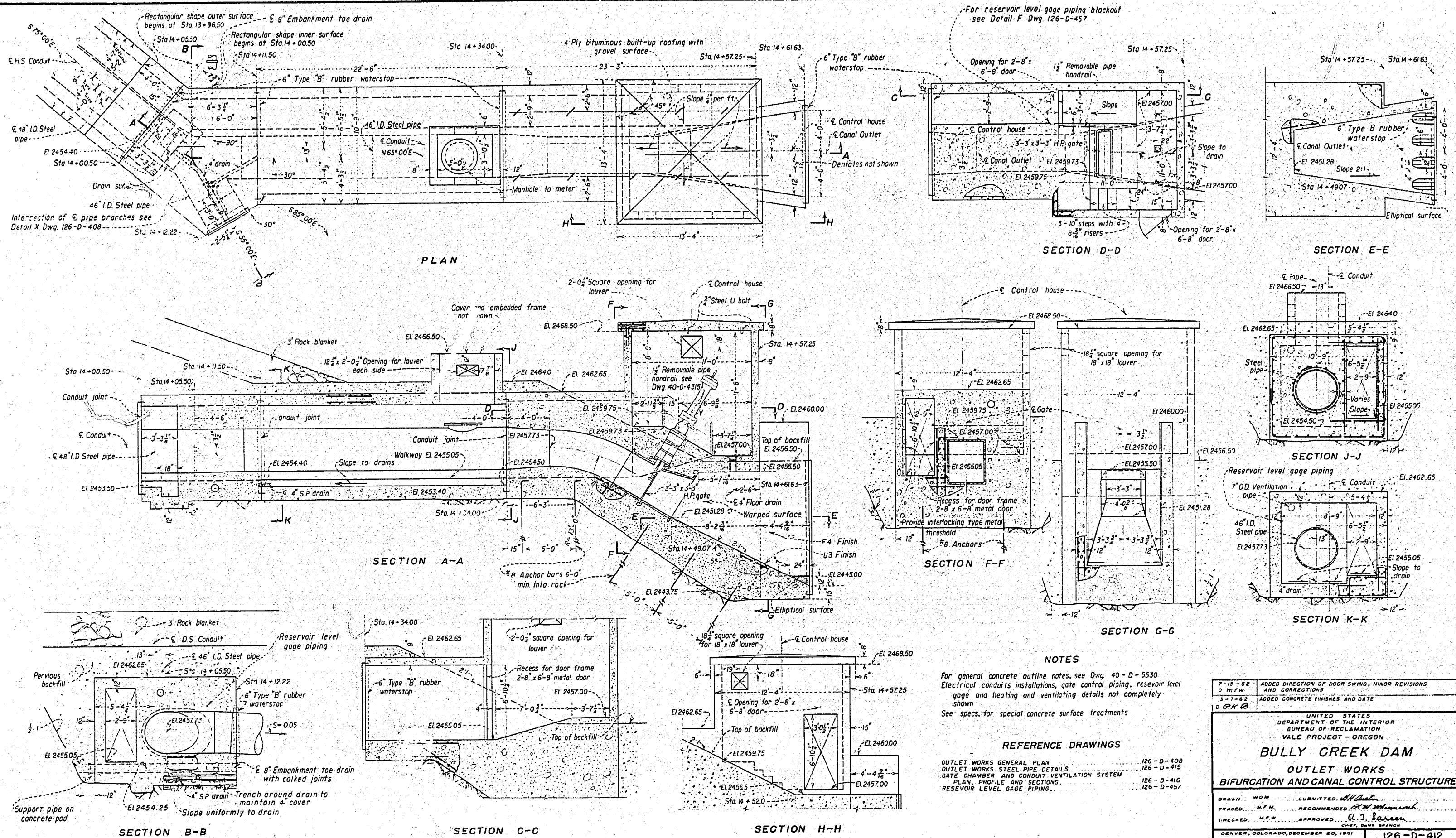
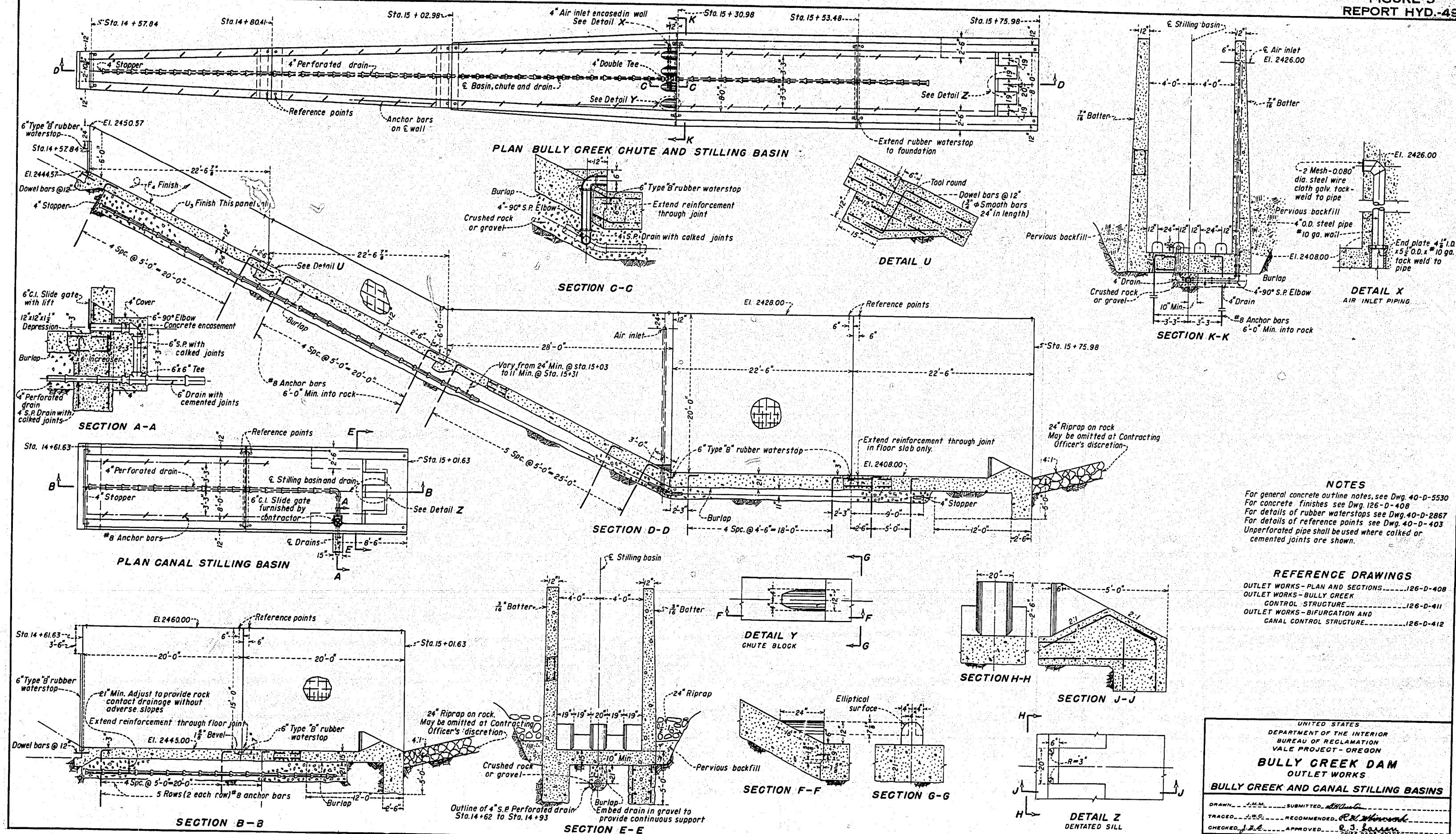
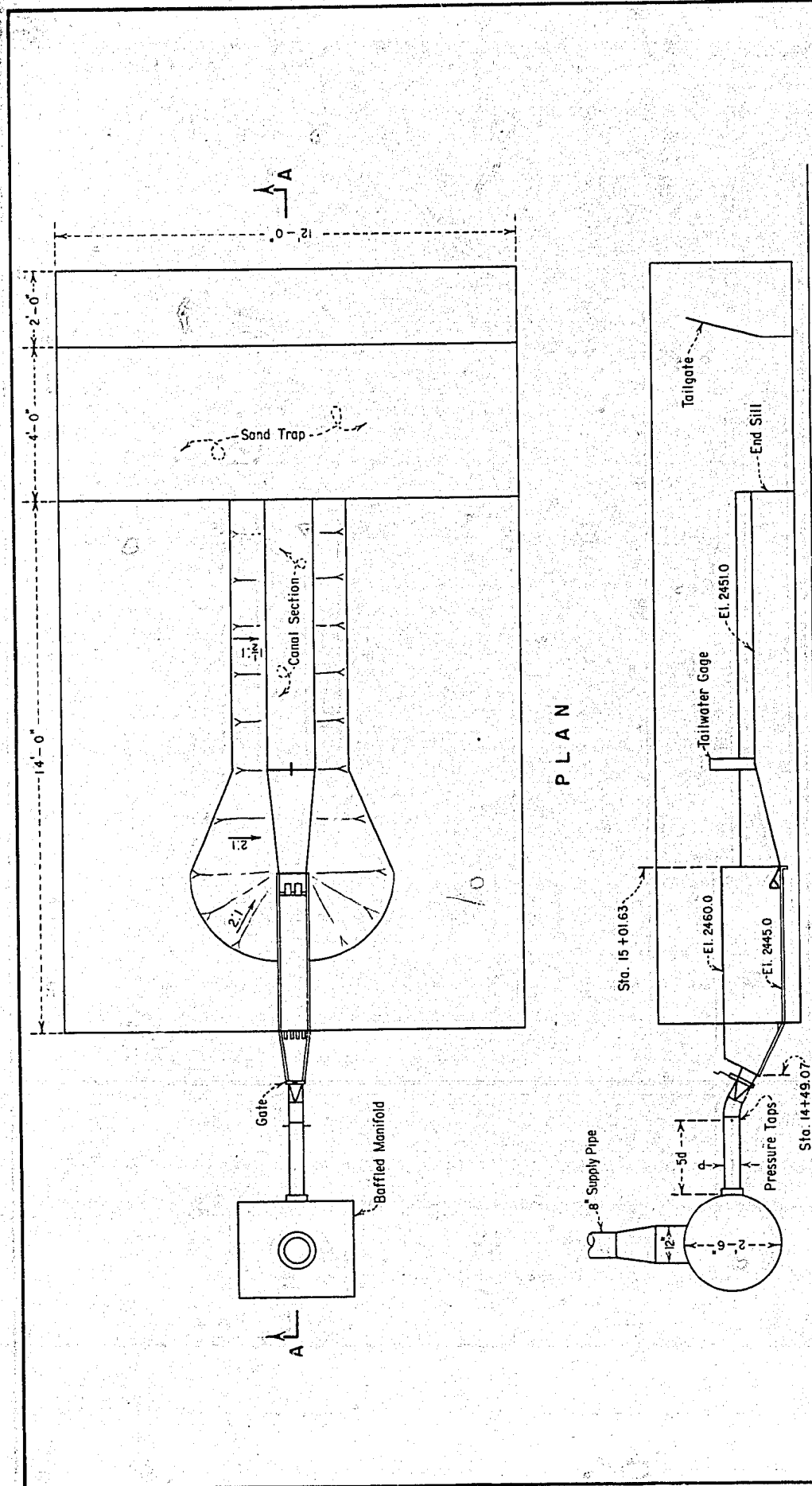
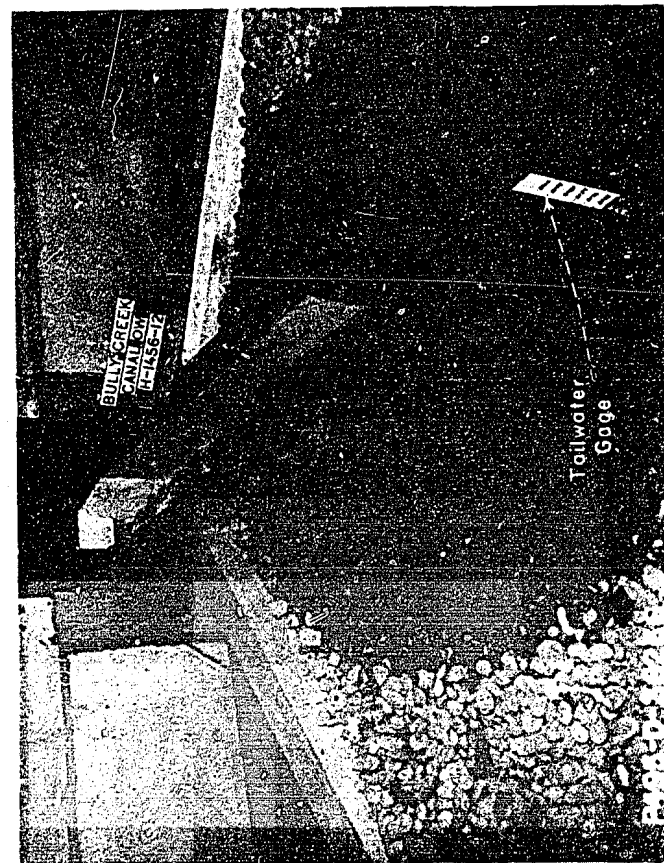


FIGURE 5
REPORT HYD.-495

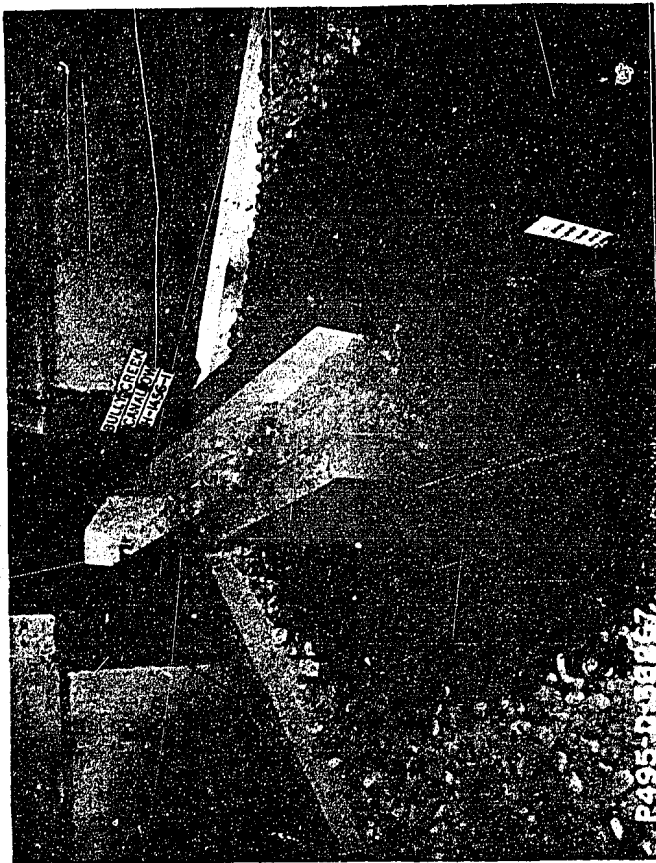




SECTION A - A
BULLY CREEK DAM
CANAL OUTLET WORKS
1:9.75 SCALE MODEL
MODEL ARRANGEMENT



Normal discharge - $Q = 110$ cfs, reservoir elevation 2516.0, tailwater elevation 2454.38.



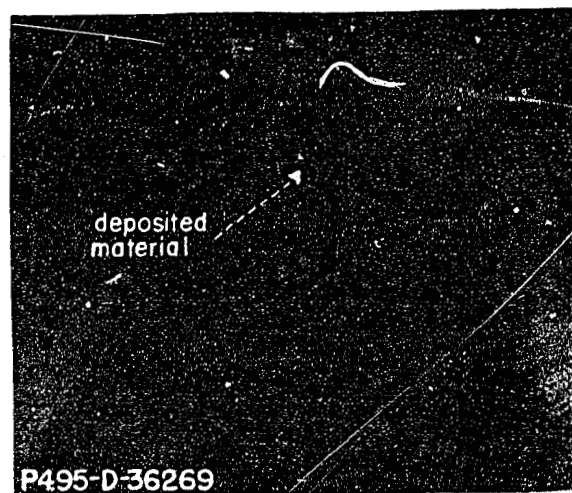
Maximum discharge - $Q = 288$ cfs, reservoir elevation 2516.0, tailwater elevation 2456.38.

**BULLY CREEK DAM
CANAL OUTLET WORKS
1:9.75 Scale Model**

Operation of Recommended Stilling Basin



A. Sand channel before erosion test.



B. Channel after 4 hours' model operation at $Q = 288$ cfs; tailwater elevation 2456.38. Note slight deposition of material at end of basin.



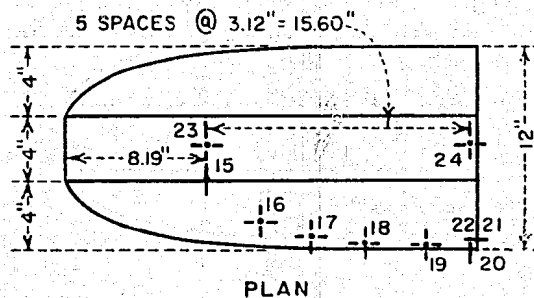
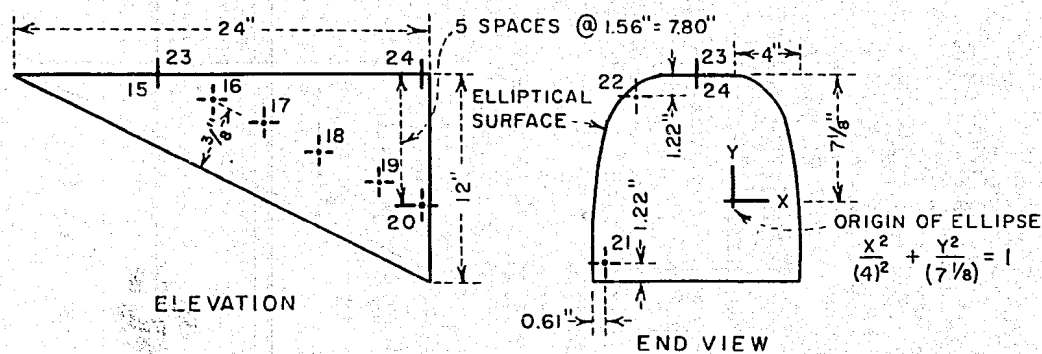
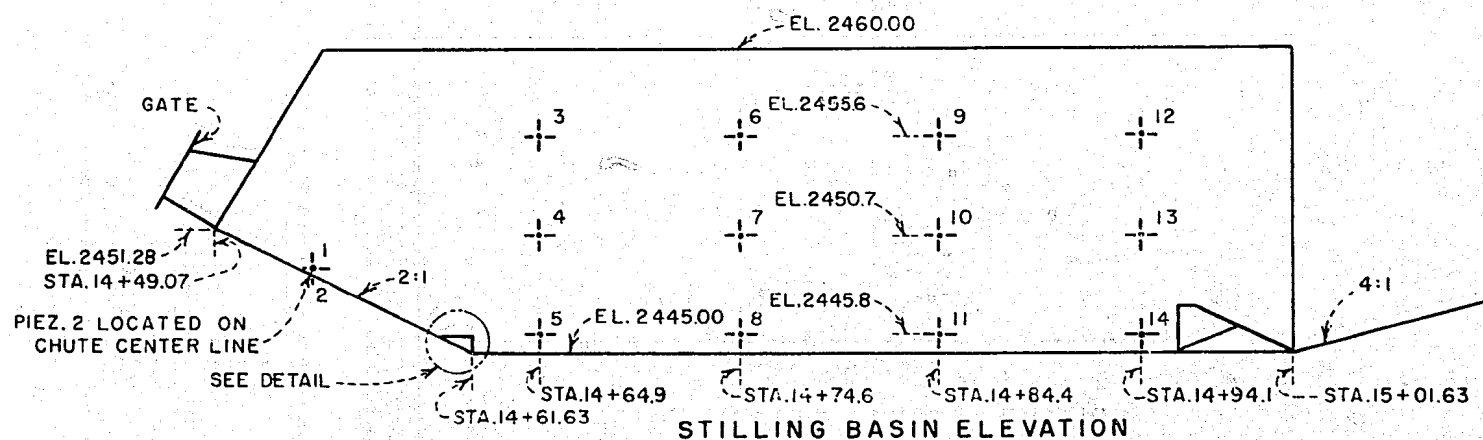
C. Placement of proposed rock riprap in channel.



D. Condition of riprap after 4 hours' model operation at $Q = 288$ cfs, tailwater elevation 2456.38.

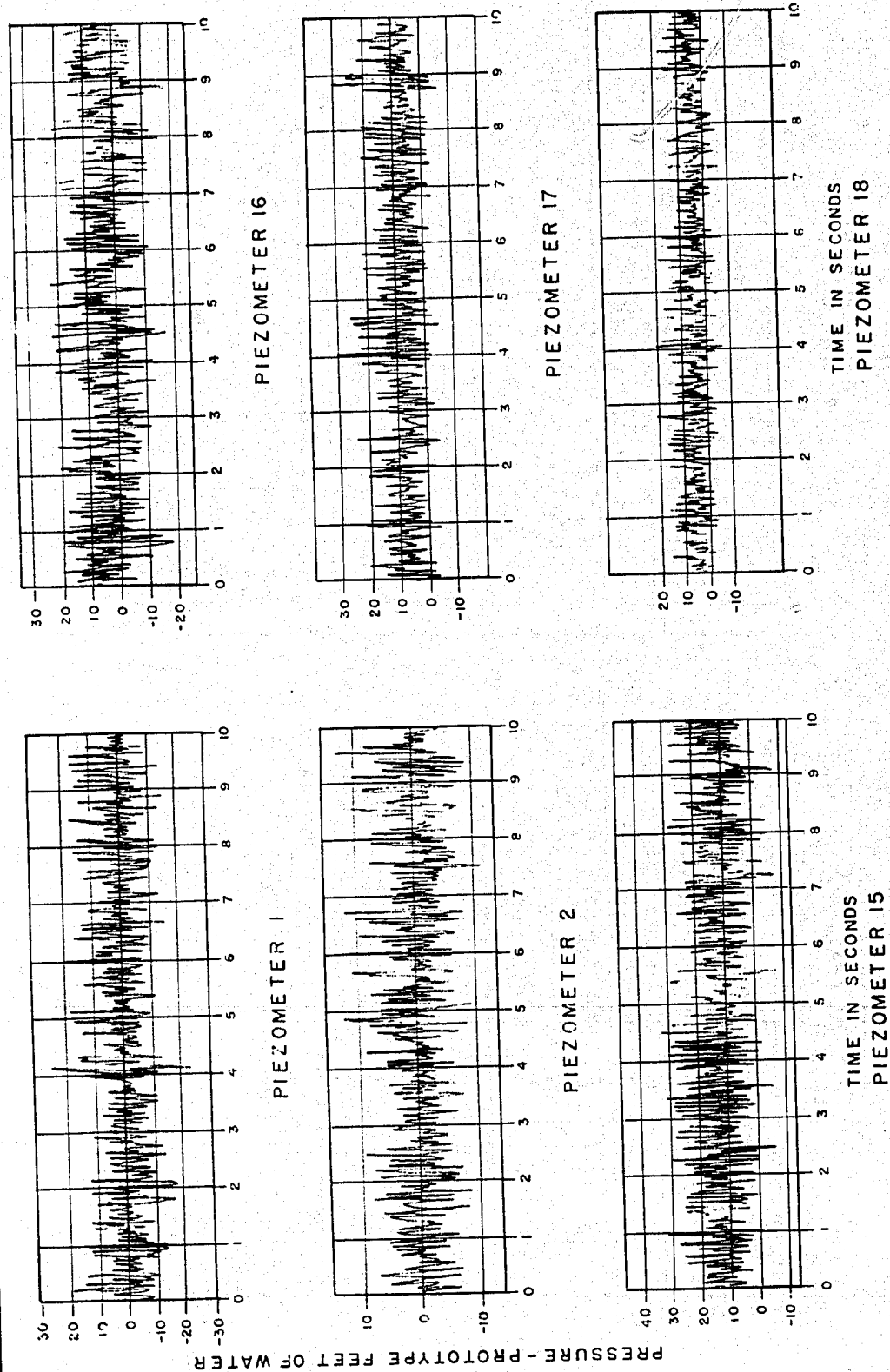
BULLY CREEK
CANAL OUTLET WORKS
1:9.75 Scale Model

Erosion and Riprap Tests



CHUTE BLOCK
DETAIL

BULLY CREEK DAM
CANAL OUTLET WORKS
1:9.75 SCALE MODEL
PIEZOMETER LOCATIONS



PRESSURE - PROTOTYPE FEET OF WATER

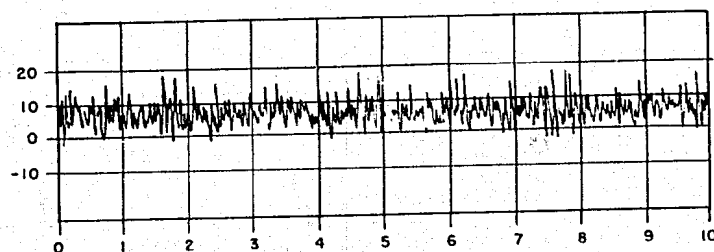
BULLY CREEK DAM
CANAL OUTLET WORKS
1:9.75 SCALE MODEL
INSTANTANEOUS DYNAMIC PRESSURE RECORDS

Q=288 SECOND-FOOT
TAILWATER EL. 2456.38
PIEZOMETER LOCATIONS - FIG. 9

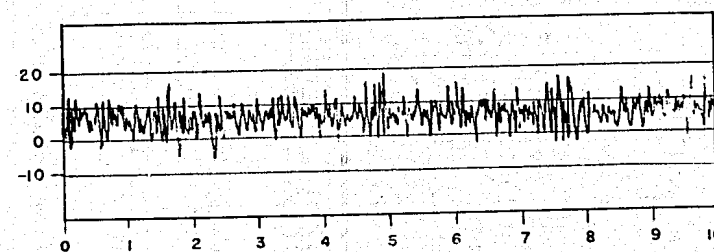
2

61

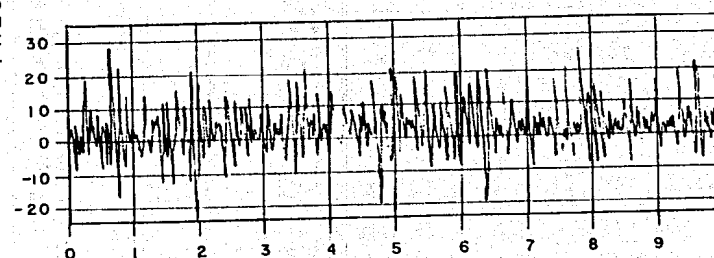
PRESSURE - PROTOTYPE FEET OF WATER



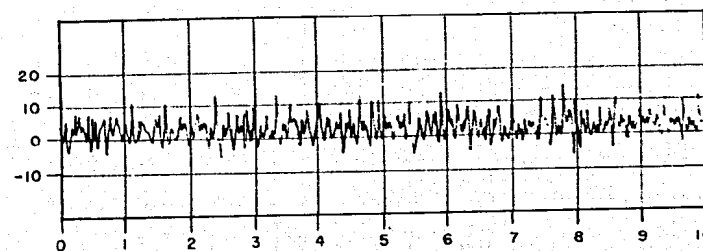
PIEZOMETER 19



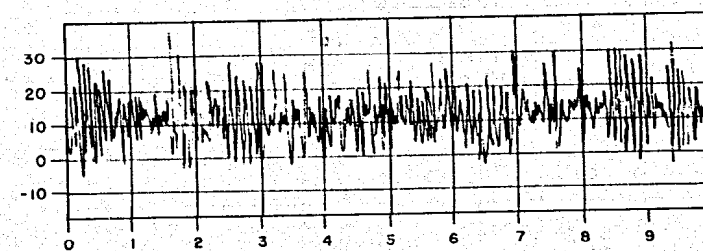
PIEZOMETER 20



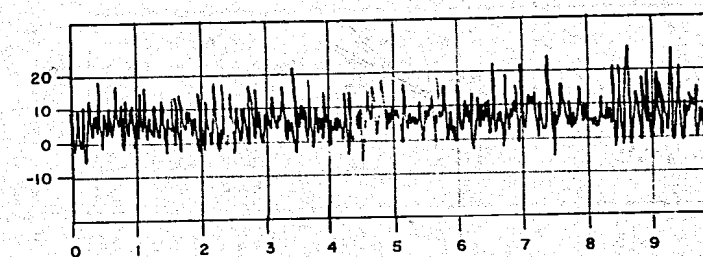
TIME IN SECONDS
PIEZOMETER 21



PIEZOMETER 22



PIEZOMETER 23



TIME IN SECONDS
PIEZOMETER 24

Q = 288 SECOND-FEET
TAILWATER EL. 2456.38
PIEZOMETER LOCATIONS-FIG. 9

**BULLY CREEK DAM
CANAL OUTLET WORKS**
1:9.75 SCALE MODEL
INSTANTANEOUS DYNAMIC PRESSURE RECORDS

SHEET 2 OF 2

FIGURE 10
REPORT HYD 495



Normal discharge - $Q = 110$ cfs,
reservoir elevation 2516.0, tail-
gate completely lowered.

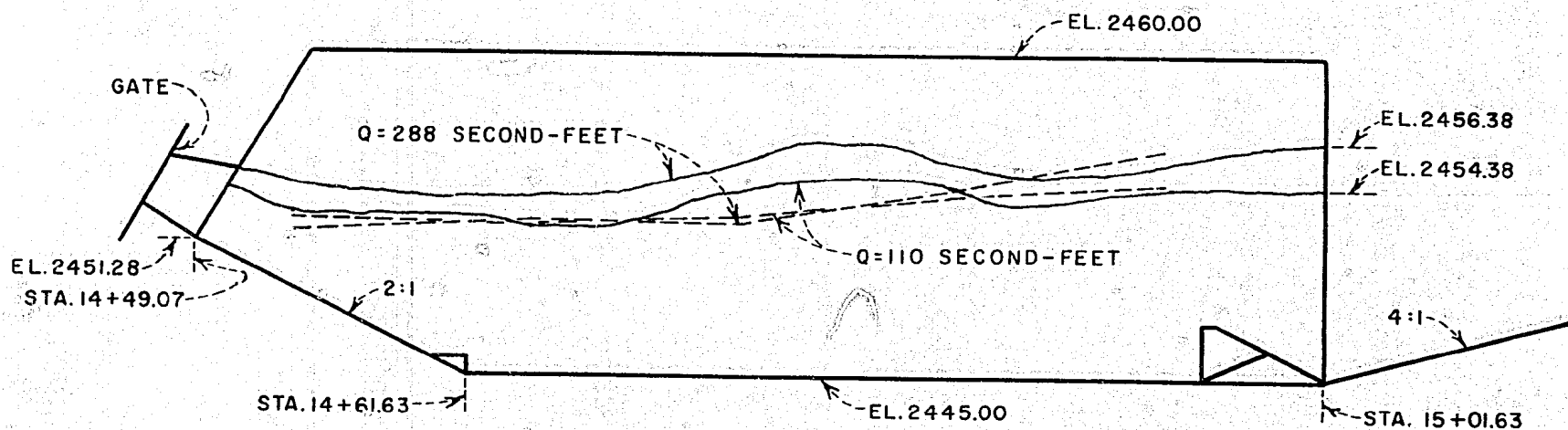


Maximum discharge - $Q = 288$ cfs,
reservoir elevation 2516.0, tail-
gate completely lowered.

BULLY CREEK DAM
CANAL OUTLET WORKS
1:9.75 Scale Model

Operation of Recommended Stilling Basin
with Tailwater Lowered - 1.4 feet

— WATER SURFACE PROFILE
- - - PRESSURE PROFILE

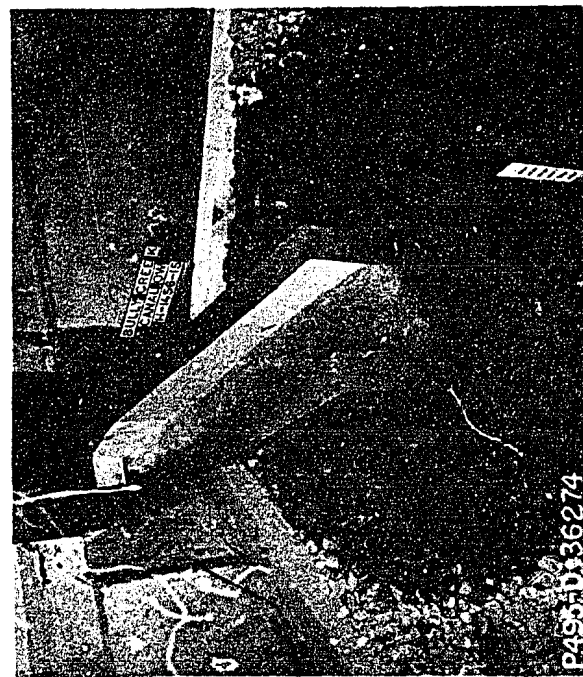


SCALE: 1" = 8'

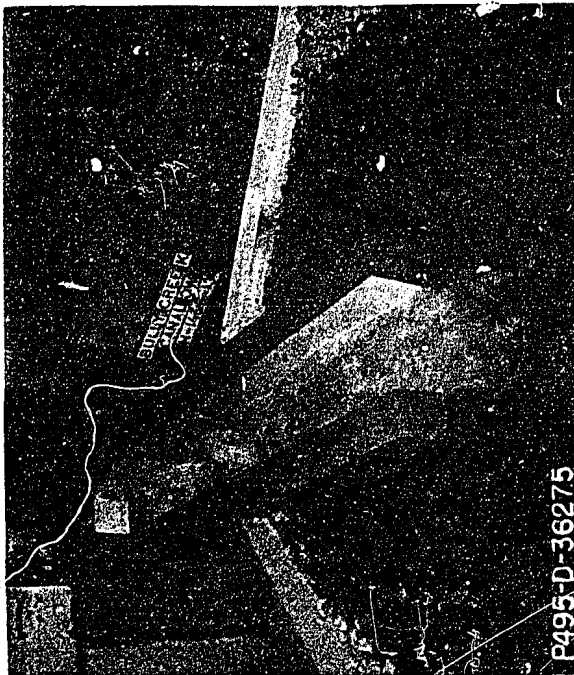
BULLY CREEK DAM CANAL OUTLET WORKS

1:9.75 SCALE MODEL

WATER SURFACE AND PRESSURE PROFILES IN RECOMMENDED STILLING BASIN



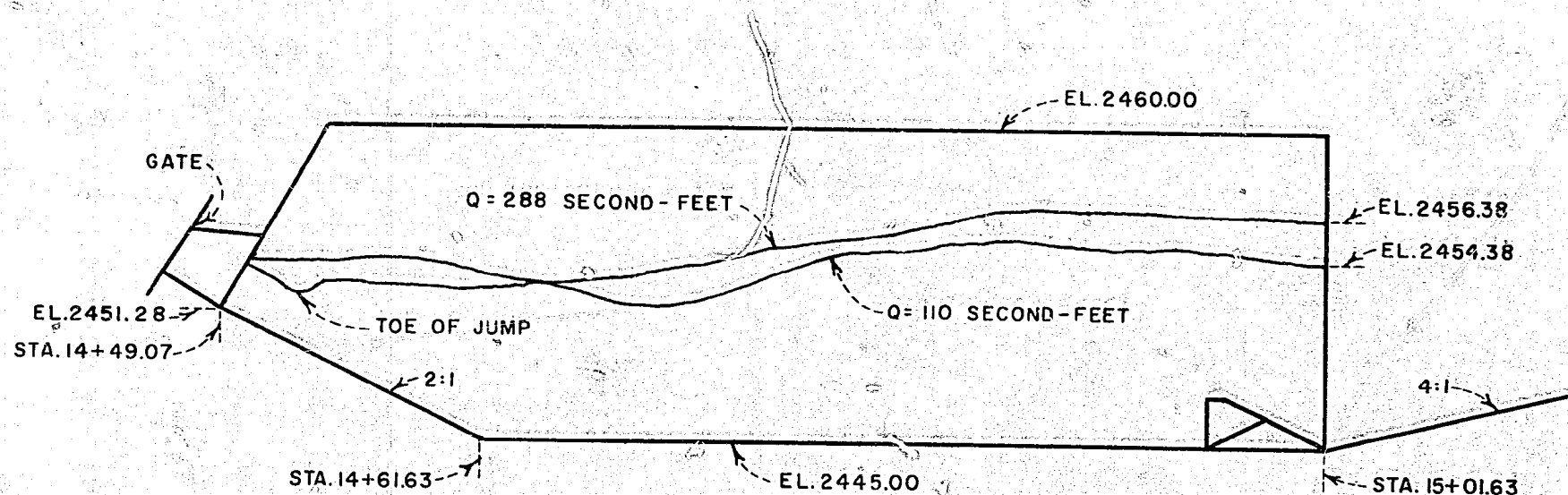
Normal discharge - $Q = 110$ cfs,
reservoir elevation 2516.0, tail-
water elevation 2454.38.



Maximum discharge - $Q = 288$ cfs,
reservoir elevation 2516.0, tail-
water elevation 2456.38.

BULLY CREEK DAM
CANAL OUTLET WORKS
1:9.75 Scale Model

Operation of Stilling Basin Without Chute Blocks



SCALE: 1" = 8'

BULLY CREEK DAM CANAL OUTLET WORKS

1:0.75 SCALE MODEL

WATER SURFACE PROFILES WITH NO CHUTE BLOCKS IN STILLING BASIN